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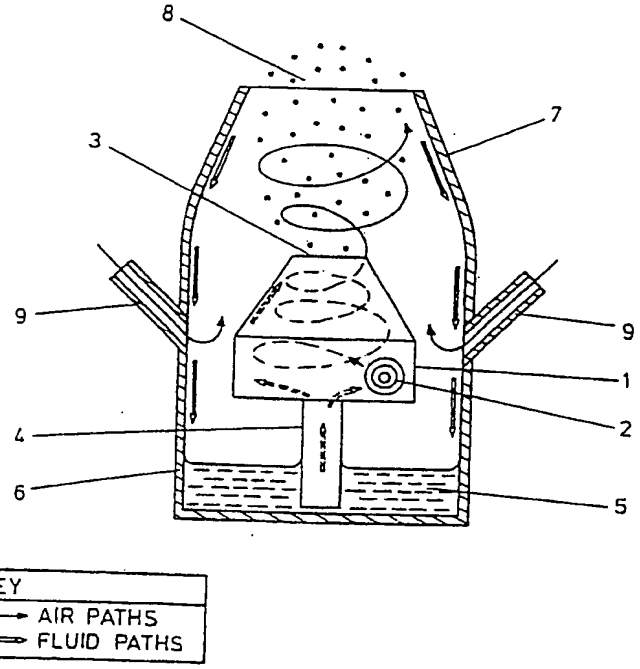

(57) Abstract

A nebuliser comprises a radially symmetrical chamber (1) extending between a first gas inlet (2), a second liquid inlet (4) and an outlet (3), the radial dimension of the second liquid inlet being smaller than that of the outlet and arranged so that liquid entering the chamber through said liquid inlet is drawn by gas passing from the first inlet to the outlet to emerge from the outlet as a spray.

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NEBULISER

This invention relates to a nebuliser arranged to produce a flow of airborne liquid droplets. The invention relates particularly but not exclusively to apparatus which may be actuated manually during attachment to the user's mouth, for example for delivery of drugs by inhalation. Alternative applications include dispersal of agrochemicals, vaporisation of fuel and other purposes wherein a finely divided spray is sought.

According to a first aspect of the present invention a nebuliser comprises a radially symmetrical chamber having a first gas inlet, a second liquid inlet and an outlet, the second liquid inlet and outlet being coaxial of the chamber, the radial dimension of the second liquid inlet being less than the radial dimension of the outlet, the nebuliser being arranged so that liquid entering the chamber through said liquid inlet is drawn by gas passing from the first inlet to the outlet and emerges from the outlet as a spray.

The chamber may be cylindrical, conical, fluted or bell shaped. It is preferred that the radius of the chamber does not increase from the liquid inlet to the outlet.

According to a second aspect of the present invention a nebuliser comprises a radially symmetrical chamber extending between a first gas inlet and an outlet, the chamber having a second inlet for liquid, the radial dimension of the chamber decreasing from the second inlet to the outlet, arranged so that liquid entering the chamber is drawn by gas passing from the first inlet to the outlet and emerges from the outlet as a spray.

The gas is preferably air although inert propellants eg nitrogen and carbon dioxide may be used as necessary.

The chamber may be conical although fluted or bell-shaped arrangements may also be employed.

In accordance with a preferred embodiment of either aspect of this invention the nebuliser includes a shroud surrounding the chamber and incorporates a reservoir for fluid, the shroud being coaxial with the chamber and the shroud further including means for admission of gas to the shroud.

The means for admission of gas may comprise vents or other apertures in the body of the shroud.

The gas inlet is preferably located tangentially to the chamber. A plurality of gas inlets may be employed.

The liquid inlet is preferably a tube connected axially at the inlet. The axial dimension of the tube may be of any convenient length consistent with the ability to draw liquid up the inlet tube from the reservoir. The diameter of the liquid inlet may be selected to afford a suitable liquid flow rate so as to yield a suitable and controllable particle size distribution

Rotation of the gas within the chamber causes liquid therein to be drawn in a spiral path along the interior wall of the chamber towards the outlet. The liquid is caused to accelerate by the decreasing radius of the chamber, forming a progressively thinner film which emerges from the outlet as a finely divided spray. The liquid is drawn into the chamber by a reduction in pressure in the chamber due to the flow of gas. Alternatively a gravity feed, mechanical pump or other means of supply may be provided. Lower driving pressures are required to produce a chosen particle size than is the case with prior art nebulisers. This is advantageous because a lower pressure pump is required or, for manual arrangements, less effort is required by a patient.

The proportion of liquid to air by volume in the spray may be small, for example 1 in 10^4, preferably 1 in 10^6 or smaller, for example 1 in 3×10^6. Pumping of air through the nebuliser requires application of less pressure than pumping of liquid. The invention affords an efficient means of providing a fine liquid spray, especially in comparison to conventional atomisers in which a body of liquid is forced through an orifice. Use of diluent liquids can be avoided.

The nebuliser may be arranged so that the axis of the chamber is disposed vertically in use. Excess fluid, for example in the form of large drops or located within the apparatus at the end of a period of use may be arranged to be returned to a reservoir. In arrangements wherein the gas inlet

is disposed above or below the outlet excess fluid may be arranged to return to the reservoir by drainage along the shroud surface.

The interior of the chamber is preferably smooth to minimise resistance. Formation of a thin liquid layer or film on the surface of the chamber is preferred to provide minimal particle size on separation at the outlet. Particle size distribution may be controlled by selection of the gas and/or liquid flow rate or gas and/or liquid inlet diameter. The liquid inlet may be divided into a multiplicity of apertures for example by means of a screen, baffle or mesh to reduce the liquid film thickness at entry.

A nebuliser in accordance with this invention may find many applications. Delivery of drugs to the lungs by inhalation is facilitated, particularly since the apparatus may have a simple construction involving no moving parts. Self administration of a drug is particularly convenient. The nebuliser may also be used for vaporisation of petrol in a carburettor of an internal combustion engine. Use in spraying apparatus, for example for dispersion of agrochemicals or for vaporisation of fuels is also facilitated. A feature of the invention is the ability to return material, in the form of larger droplets which would otherwise be wasted, to a reservoir.

The apparatus may be actuated using a low pressure gas supply, particularly when using a tangential inlet which creates a much reduced pressure within the vortex chamber.

The apparatus may be employed to disperse liquids, finely divided solids or mixtures thereof. The need for diluents is reduced or eliminated.

Manufacture of the apparatus is simplified by the lack of moving parts and the need for components fabricated to high tolerances.

The invention is further described by means of example but not in any limitative sense with reference to the accompanying drawings of which:

Figure 1 is a cross-section through a nebuliser in

accordance with this invention;

Figure 2 is a plan view of the nebuliser shown in Figure 1;

Figure 3 is a diagrammatic view of a further embodiment of the invention;

Figure 4 is a diagrammatic view of a further embodiment of the invention;

Figures 5 is three views illustrating nomenclature of dimensions;

Figure 6 illustrates various views of a nebuliser in accordance with this invention;

Figure 7 illustrates various views of an alternative nebuliser in accordance with this invention;

Figure 8 illustrates operation of the nebuliser shown in Figure 6;

Figure 9 illustrates operation of the nebuliser shown in Figure 7; and

Figure 10 shows a nebuliser having a shroud.

The apparatus shown in Figures 1 and 2 comprises a vortex chamber 1 having a lower cylindrical portion through which an inlet 2 is arranged to provide a supply of air or other propellant gas. The chamber 1 is radially symmetrical and has a conical portion wherein the radius decreases towards an upper outlet 3. An inlet for liquid 4 communicates with a reservoir 5 containing a supply of liquid to be dispersed. A shroud 6 surrounds the chamber 1 and is provided with vents 9 through which air or other gas may enter the apparatus. An outlet 8, coaxial with the chamber 1 allows the liquid spray to pass from the apparatus in use. Larger droplets emerging from the outlet 3 are collected on the interior surface 7 of the shroud and are allowed to return to the reservoir under the action of gravity. In use of the apparatus for inhalation of drugs, a user places his mouth over the outlet 8 and breathes in. Air is supplied through the gas inlet 2 causing liquid to rise from the reservoir 5 which is then dispersed as a thin film on the interior surface of the chamber 1. The thin film breaks up into a spray at the outlet 3 and may be drawn into the user's

mouth along with air through the vents 9. In alternative embodiments of the invention there may not be a low pressure pump or other gas supply to the inlet 2. Figure 3 is a diagrammatic representation of the arrangement shown in Figures 1 and 2 but wherein the shroud 6 has been omitted. The gas supply 11 may be delivered under pressure to the apparatus to provide consistent delivery of the spray. Excess fluid within the chamber 14 may return to the reservoir 13 by drainage through the inlet pipe 12 when the air supply is shut off.

Figure 4 illustrates an alternative embodiment wherein the aerosol spray 20 is delivered downwardly, the inlet 21 being disposed above the outlet 22 of the chamber 23. In this embodiment liquid is drawn from the reservoir 24 through an inlet pipe 25 but excess fluid may collect on the exterior of the pipe 25 and drain along it to return to the reservoir. Also excessively large droplets from the outlet 22 will be caught in the reservoir 24.

Although the apparatus does not require manufacture to high dimensional tolerances, the following dimensions have been found to be useful. Referring to Figure 5 the nozzle diameter g would usually be greater than the inlet diameter a. The ratio of chamber diameter f to inlet diameter should be between 2 and 20 dependent on the required flow rate. The ratio of air inlet major diameter d to air inlet minor diameter e may be approximately 4 so that the air inlet speed will be accelerated merely by reduction in the inlet pipe diameter. The length of the conical portion, c, may be from 0 to twice the width of the chamber, f. The length of the neck, b, may be from 0 to 4d.

As an example for use in drug inhalation the following dimensions, for the vortex chamber, may be employed (mm):

a = 1.0;
b = 2.5;
c = 5.0;
d = 6.0;
e = 1.5;
f = 20.0;

g = 2.5.

In such an application, the exterior chamber is used as a baffling arrangement to return oversize (ie non-respirable) particles to the drug reservoir.

A flow rate of 16 l min^{-1} may be employed to produce respirable particles at a pressure drop of less than 700g cm^{-2} across the apparatus.

Figure 6 illustrates a nebuliser in accordance with this invention comprising a radially symmetrical chamber having an inlet 30 for liquid disposed axially thereof and an outlet 29 for the spray. The diameter of the outlet 29 is greater than the inlet 30. The Inlet 30 comprises an axially extending tube arranged to communicate with a reservoir of liquid in use. An inlet 31 for compressed air communicates tangentially with the cylindrical lower portion of the radially symmetrical chamber. The upper portion of the chamber is shaped conically and decreases from the lower portion at which the air inlet 31 is connected to the apical outlet 29.

Figure 7 illustrates an alternative nebuliser comprising a generally cylindrical chamber having an outlet 35 and inlet 36 disposed axially thereof. The diameter of the outlet 35 is greater than that of the inlet tube 36. A low pressure gas supply 37 extends tangentially of the chamber.

Use of the nebuliser shown in Figure 6 is illustrated in Figure 8. Rotation of air delivered from the tangential inlet 31 (not shown) towards the outlet 29 causes liquid 41 to be drawn from the inlet tube 44. The direction of rotation of gas carrying entrained liquid droplets is shown at 43. The liquid is caused to pass in a spiral manner from the cylindrical wall 39 of the chamber and across the conical wall portion 40. Upon reaching the outlet 29 the liquid film disintegrates to form a conical spray 42.

Figure 9 illustrates use of the nebuliser shown in Figure 7. Air from the tangential (not shown) inlet is caused to rotate within the chamber as shown at 50. Liquid drawn from the inlet tube 51 rotates along the lower wall 48 of the chamber, the cylindrical side wall 47 and across the upper

surface 46. The film disintegrates at the outlet 35 to form a conical spray 49. Suction created by the passage of air through the chamber is arranged to be sufficient to draw liquid from the reservoir (not shown) through the tube 51. The diameter of the tube 51 may be selected to control the flow rate of liquid into the chamber.

Figure 10 illustrates a nebuliser, particularly adapted for use in medical applications. A cylindrical chamber having an outlet 56, liquid inlet tube 57 and tangential gas inlet 58 is disposed within a generally cylindrical shroud 53. The liquid inlet tube 57 communicates with a lower reservoir 59 in which liquid 60 is received. The upper portion of the shroud 53 is partially enclosed 54 to define an aperture 55 through which spray is drawn. The nebuliser liquid 60 is drawn into the cylindrical chamber through the inlet tube 57 by action of air or other gas supplied from the gas inlet 58. Spray emergent from the outlet 56 passes through the orifice 55, for example into a user's mouth. Oversized particles of spray are retained by the shroud 53 and baffle 54 and are allowed to drain into the reservoir 60 for reuse.

In alternative embodiments of the invention a nebuliser may be adapted to operate in orientations other than vertical. The reservoir may be enclosed to prevent spillage of liquid and the inlet tube 57 may be correspondingly shaped. For example a flexible tube 57 may communicate with a reservoir 60 held externally of the shroud 53.

CLAIMS

1. A nebuliser comprising a radially symmetrical chamber having a first gas inlet, a second liquid inlet and an outlet, the second liquid inlet and outlet being coaxial of the chamber, the radial dimension of the second liquid inlet being less than the radial dimension of the outlet, arranged so that liquid entering the chamber through said liquid inlet is drawn by gas passing from the first inlet to the outlet and emerges from the outlet as a spray.

2. A nebuliser comprising a radially symmetrical chamber extending between a first gas inlet and an outlet, the chamber having a second inlet for liquid, the radial dimension of the chamber decreasing from the second inlet to the outlet, arranged so that liquid entering the chamber is drawn by gas passing from the first inlet to the outlet and emerges from the outlet as a spray.

3. A nebuliser as claimed in claim 2 wherein the chamber is conical.

4. A nebuliser as claimed in any preceding claim wherein the first gas inlet is tangential to the chamber.

5. A nebuliser as claimed in any preceding claim, including a shroud surrounding the chamber and incorporating a reservoir for fluid, the shroud being coaxial with the chamber and the shroud further comprising means for admission of gas into the shroud.

6. A nebuliser as claimed in claim 5, wherein the chamber is disposed vertically in use.

7. A nebuliser as claimed in claim 6 wherein excess liquid is returned in use to the reservoir by drainage on the surface of the shroud.

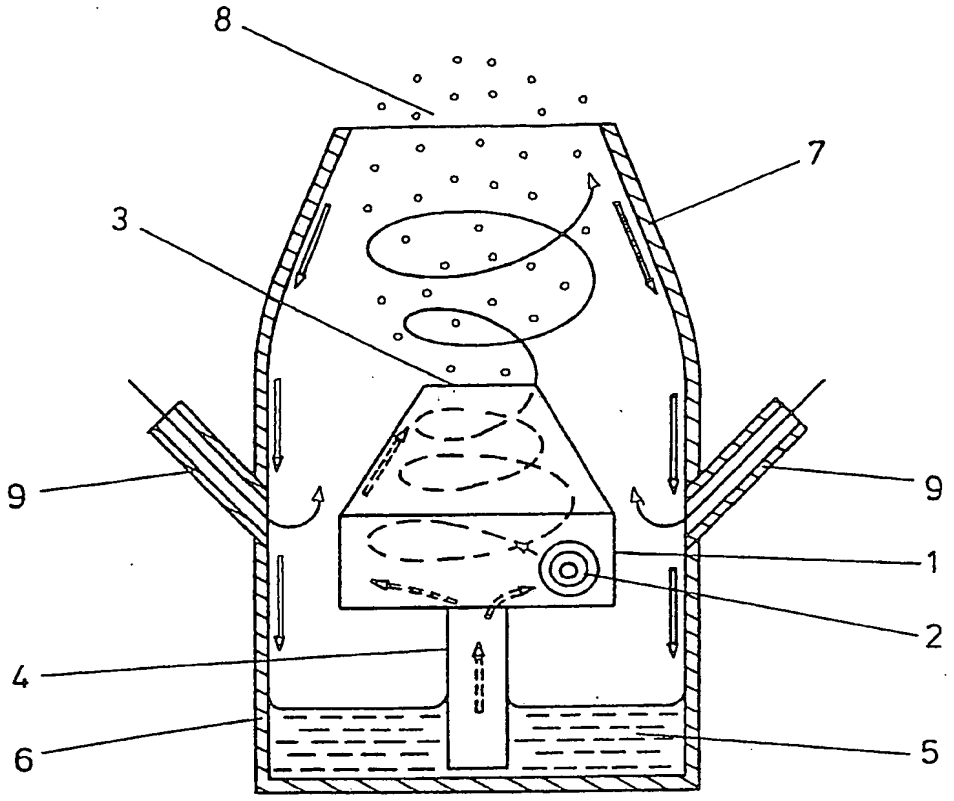
8. A nebuliser as claimed in any preceding claim wherein the liquid inlet comprises cylindrical bore disposed axially of the chamber.

9. A drug inhaler comprising a nebuliser as claimed in any preceding claim.

10. An agrochemical sprayer comprising a nebuliser as claimed in any of claims 1 to 8.

11. A carburettor for an internal combustion engine including a nebuliser as claimed in any of claims 1 to 8.

12. A fuel vaporiser for a liquid fuel burner including a nebuliser as claimed in any of claims 1 to 8.



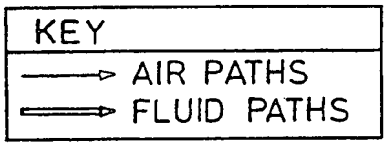


FIG. 1

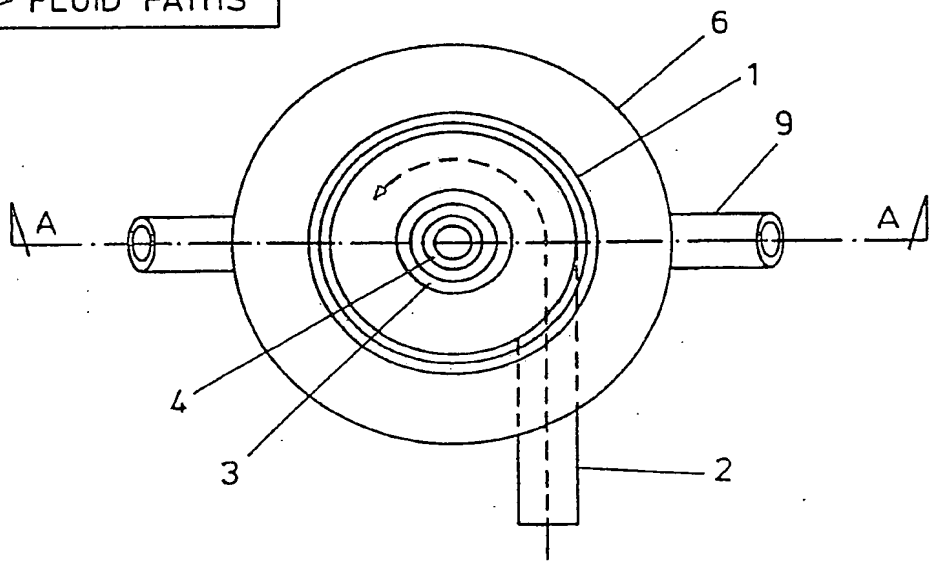


FIG. 2

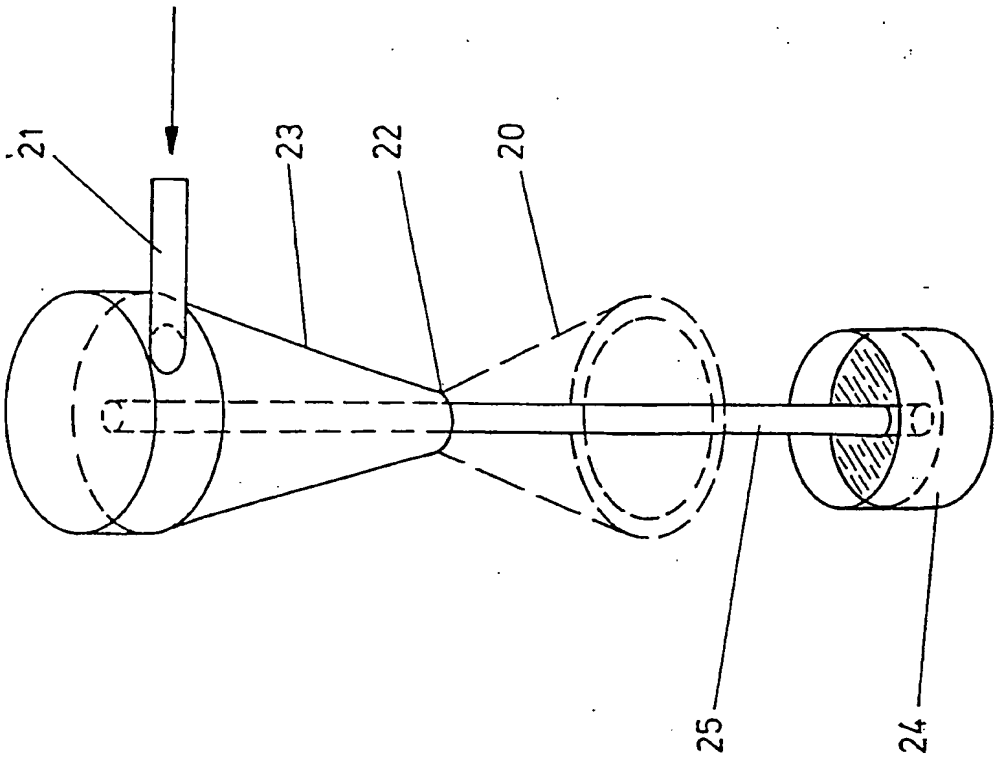


FIG. 4

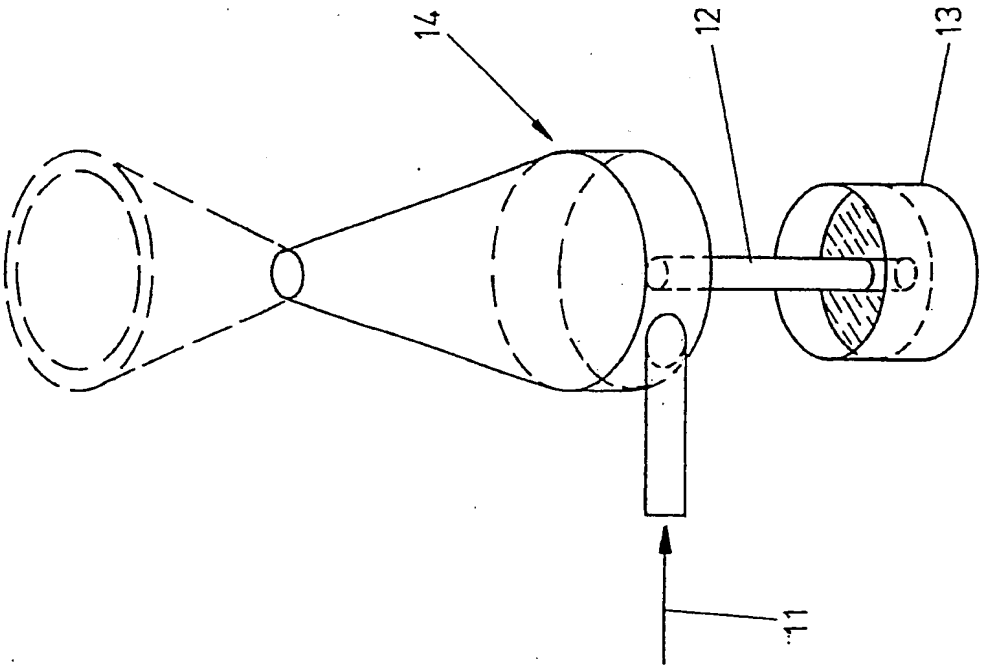


FIG. 3

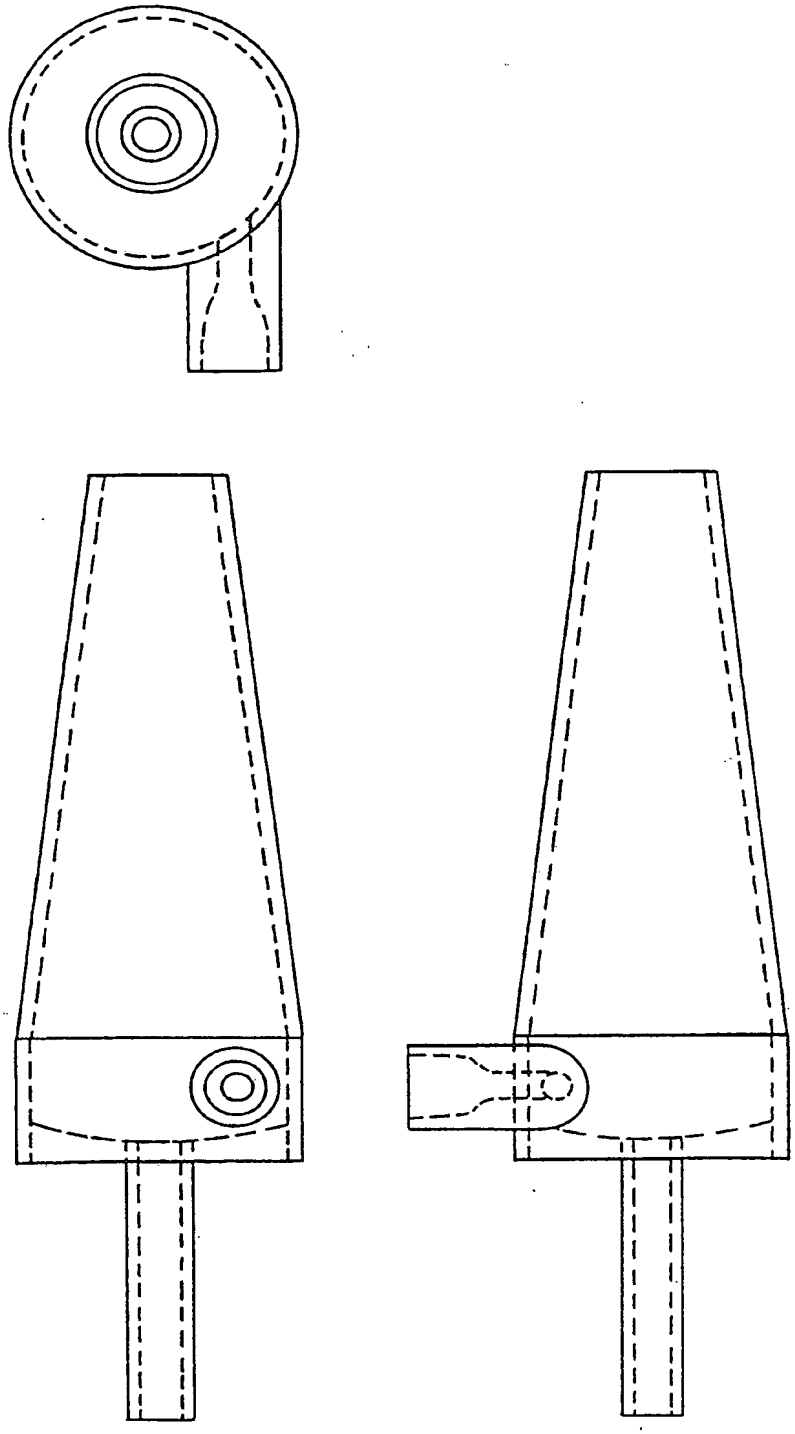


FIG. 5

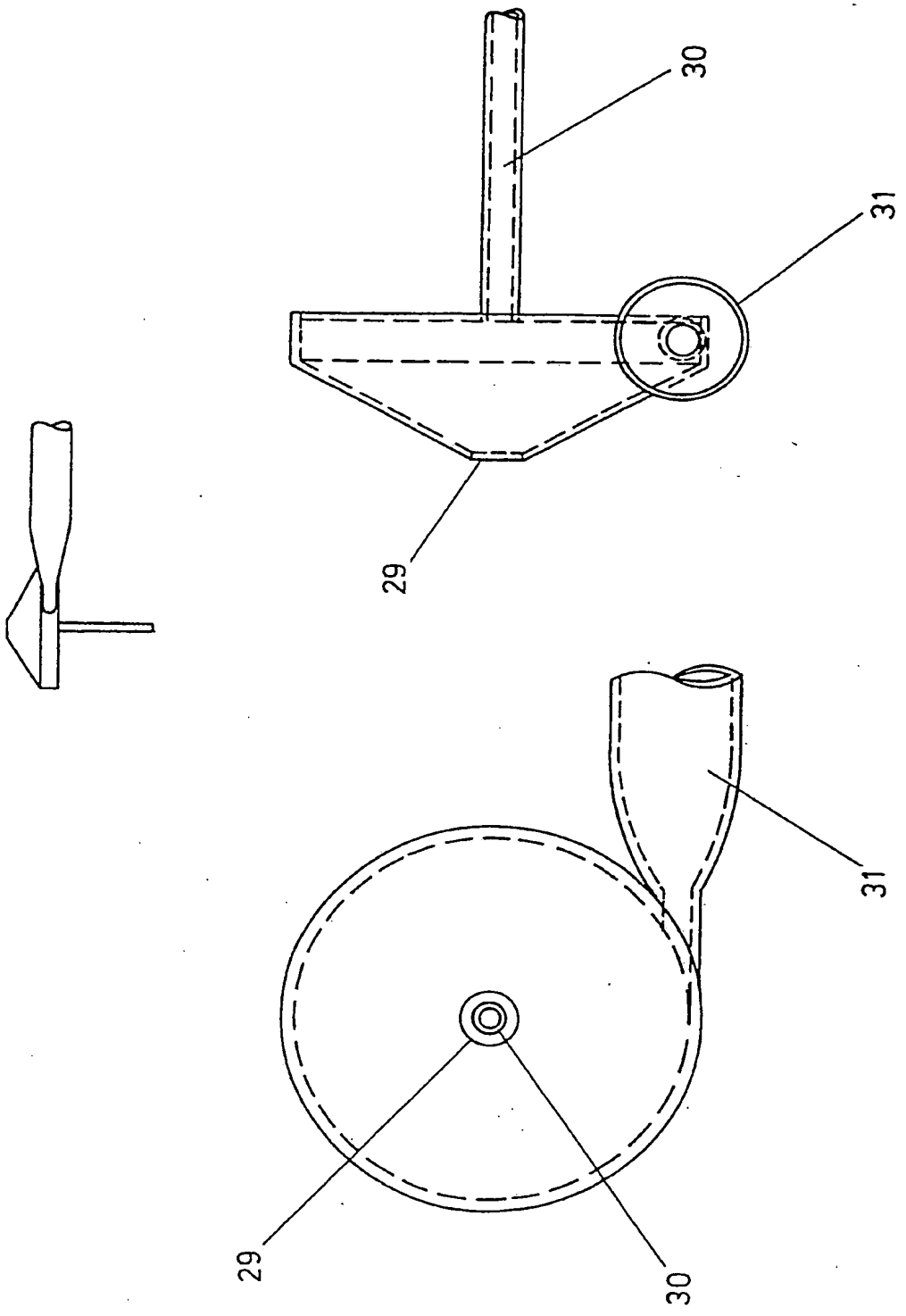


FIG. 6

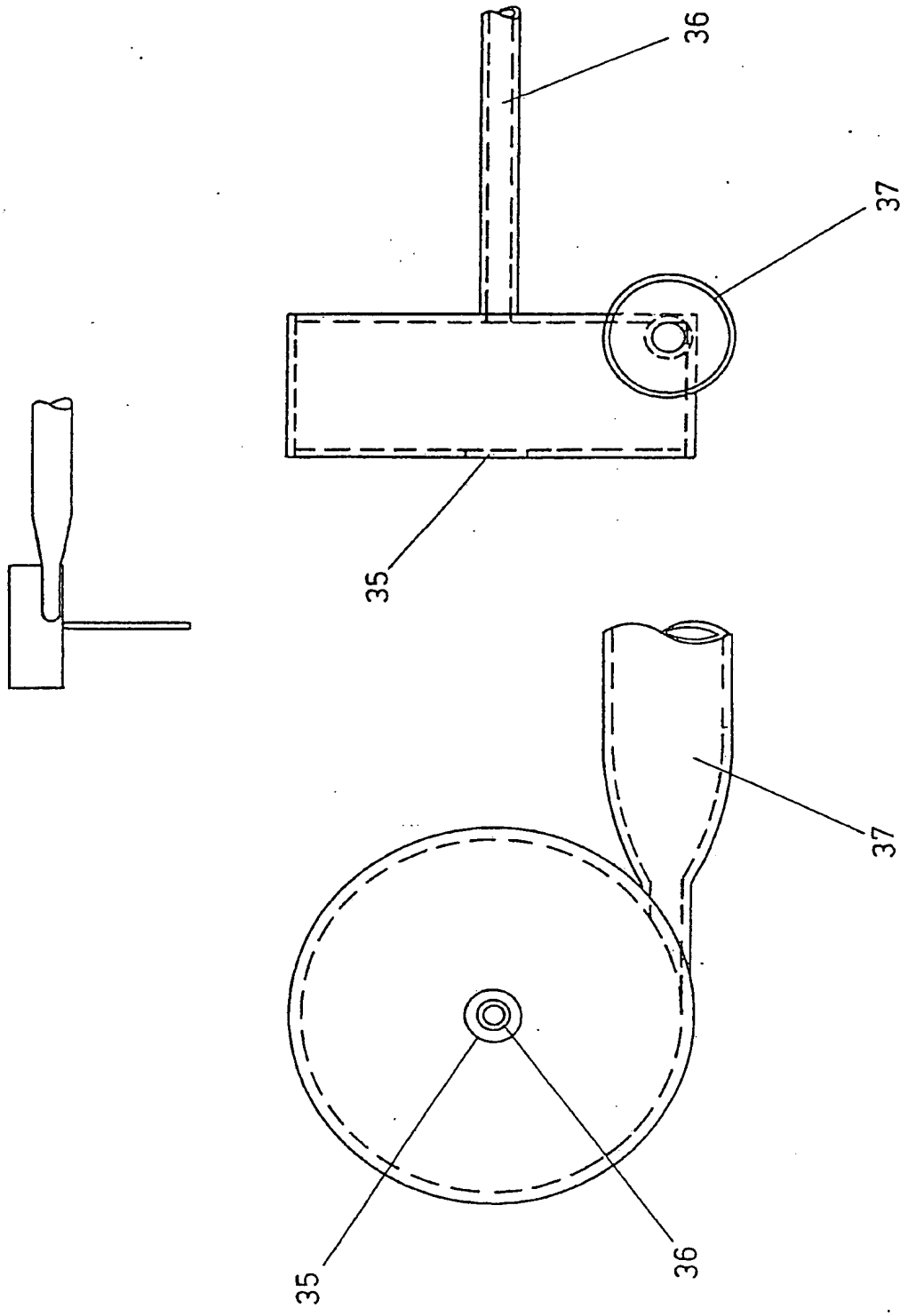


FIG. 7

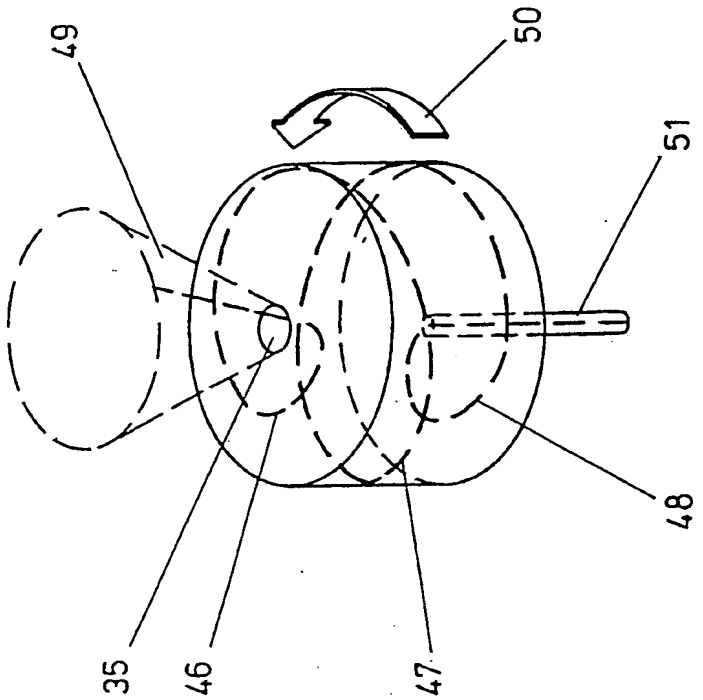


FIG. 9

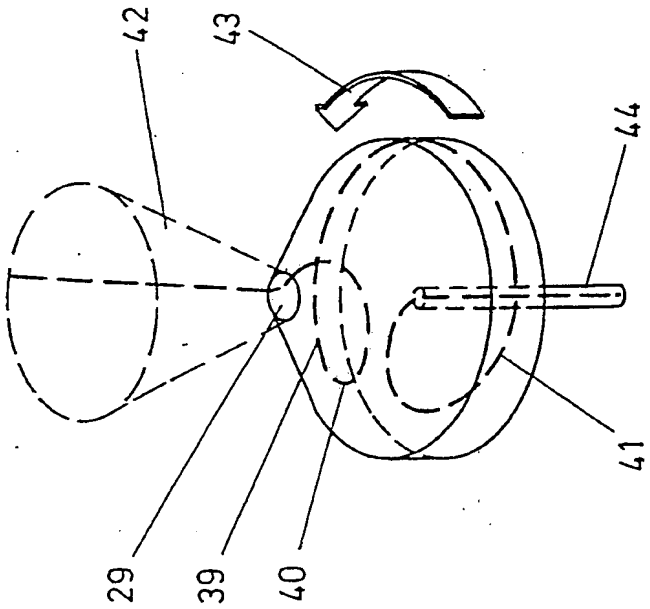


FIG. 8

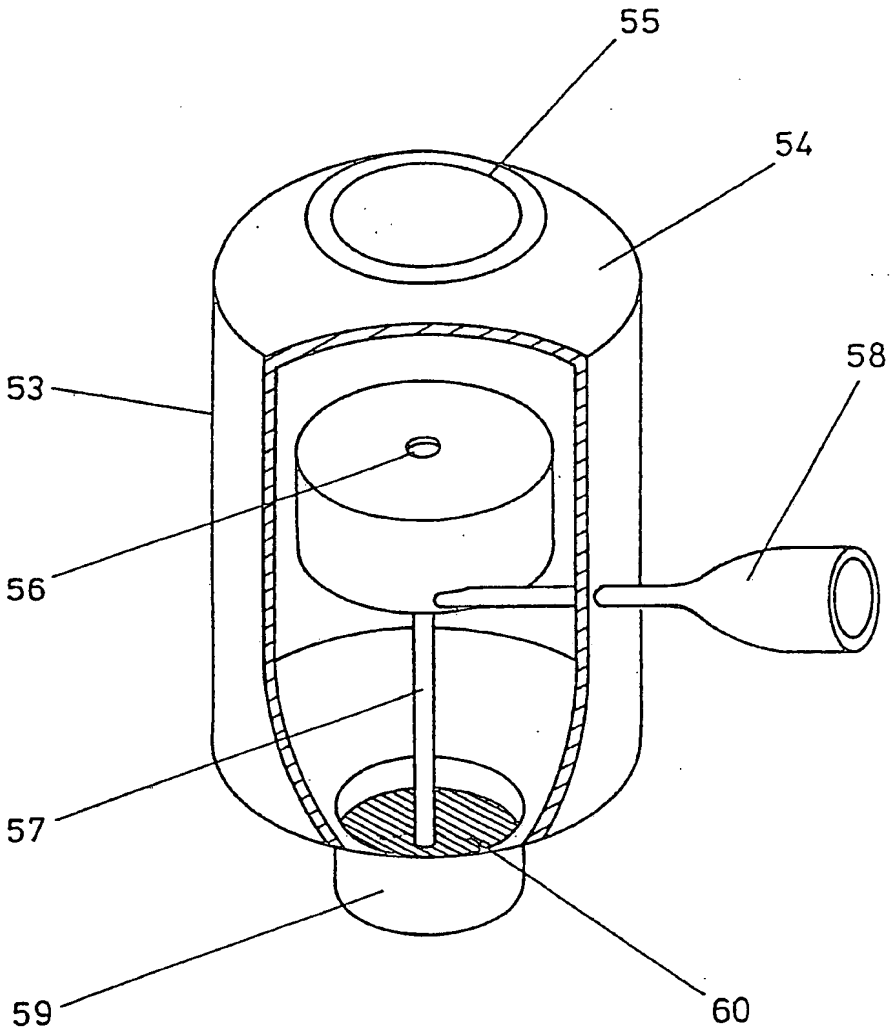


FIG. 10

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 92/01240

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 B05B7/10; A61M11/06

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	B05B ; A61M

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X Y	AU,B,517 254 (RHÔNE - PROGIL SA) 16 July 1981 see page 14, line 22 - line 24; claim 5; figures 1,2	1-4,8,12 5-7,9-11
X	WO,A,8 101 186 (DALA INVEST AB) 30 April 1981 see abstract; figure 1A	1-3,8,12
Y	FR,A,2 573 985 (LA DIFFUSION TECHNIQUE FRANCAISE SARL) 6 June 1986 see page 2, line 14 - page 3, line 8 see page 4, line 8 - line 30; figures 1-3	5-7,9
Y	US,A,4 884 746 (LEWIS) 5 December 1989 see column 4, line 55 - column 5, line 21; figures 1-3	11

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
30 SEPTEMBER 1992	13. 10. 92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	VILLENEUVE J.M.

International Application No

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
Y	GB,A,640 808 (CHARLES AUSTEN LTD) 26 July 1950 see page 1, line 22 - line 39; claims	10
A	FR,A,989 494 (ROLLAND) 23 May 1951 see abstract; figures	11
A	FR,A,1 152 856 (SFERI-COANDA) 11 June 1953	-

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
AU-B-517254	16-07-81	AU-A- 3517878	20-07-78
WO-A-8101186	30-04-81	AT-T- 3906	15-07-83
		CA-A- 1159356	27-12-83
		EP-A,B 0028025	06-05-81
		SE-A- 7908863	26-04-81
		US-A- 4473185	25-09-84
		SE-A- 7908864	26-04-81
		DE-A- 3040215	14-05-81
		SE-A- 7908865	26-04-81
FR-A-2573985	06-06-86	None	
US-A-4884746	05-12-89	None	
GB-A-640808		None	
FR-A-989494		None	
FR-A-1152856		None	

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